CLAIMS

We claim:

1. A device for controlling fluid flow in a microchannel, comprising:

a mobile, monolithic polymer element disposed in the microchannel, wherein said mobile, monolithic polymer element is made by polymerizing a monomer mixture within the microchannel; and

means for providing a displacing force to control the movement of said polymer element in the microchannel.

2. The device of claim 1, wherein the displacing force is pressure or voltage.

3. The device of claim 1, further including spaced apart retaining means disposed within the microchannel.

4. The device of claim 3, wherein said retaining means comprises a sealing surface.

5. A method for making a mobile, monolithic polymer element in a microchannel, comprising;

a) injecting a monomer mixture dissolved in a solvent into the microchannel, wherein the composition of the monomer mixture is such that the polymer formed by polymerizing the monomer does not bond to the microchannel wall;

b) polymerizing the monomer by application of radiation; and

c) flushing unpolymerized monomer mixture from the microchannel.

6. The method of claim 5, wherein the radiation is UV, visible, or thermal radiation.

7. A method for making a monolithic polymer element in a microchannel such that the polymer element conforms to the configuration of the microchannel and does not bond to the microchannel wall, comprising the steps of:

preparing a monomer mixture by mixing together

a) one or more cross-linking agents selected from the group including ethylene glycol diacrylate, diethylene glycol diacrylate, propylene glycol diacrylate, butanediol diacrylate, neopentyl glycol diacrylate, hexanediol diacrylate, pentaerythritol triacrylate, pentaerythritol tetracrylate, trimethylolpropane triacrylate, or divinyl benzene,

b) tetrahydrofurfuryl acrylate,

c) at least one nonpolar monomer selected from the group branched or straight chain C_1-C_{12} alkyl acrylates, or styrene, and

d) at least one monomer capable of carrying a charge at a pH of between about 2 and 12 selected from the group including C_1-C_{12} alkyl or aryl acrylates substituted with sulfonate, phosphate, boronate, carboxylate, amine, or ammonium;

adding the monomer mixture to a solvent, comprising;

a) water containing up to 100 mM buffer salts, and

b) at least one of the group including C_1-C_6 alcohols, C_4-C_8 ethers, C_3-C_6 esters, C_1-C_4 esters, C_1-C_4 carboxylic acids, methyl sulfoxide, sulfolane, or N-methyl pyrrolidone, and

a polymerization initiator,

wherein the monomer/solvent mixture forms a single phase mixture at a temperature below about 40 °C;

loading the combined mixture into a capillary tube;

applying a mask to the surface of the capillary tube, wherein the mask defines the shape of the polymer monolith to be produced;

polymerizing the combined mixture by exposing the monomer mixture to radiation through the mask; and

flushing unpolymerized monomer from the microchannel.

8. The method of claim 7, wherein the radiation includes thermal, visible, or UV radiation.

9. The method of claim 8, wherein wavelength of the radiation is greater than about 257 nm.

10. A mobile polymer monolith disposed in a microchannel and made by the method of claim 7.

11. A device for controlling fluid flow in a microchannel, comprising

a mobile monolithic polymer element disposed in the microchannel, wherein said polymer element is made by the method of claim 7;

at least one retaining means disposed in the microchannel; and

means for applying a displacing force to the either end of the microchannel.

12. A device for increasing fluid flow rates in a capillary, comprising:

a first and a second capillary joined together coaxially, wherein said first capillary has a larger diameter than said second capillary; and

a mobile monolithic polymer element disposed in said first capillary.

13. A device for amplifying fluid forces in a capillary, comprising:

a first and a second capillary joined together coaxially, wherein said first capillary has a larger diameter than said second capillary; and

a mobile monolithic polymer element disposed in said first capillary, wherein said polymer element consists of a first and second coaxial segments, and wherein the second segment has a diameter adapted to fit within the second capillary.

14. A rotational flowmeter, comprising:

a microchannel system disposed on a substrate, the microchannel system comprising a microchannel intersecting a cavity, wherein the cavity divides the intersecting microchannel into an inlet channel and an outlet channel; and

a rotatable polymer disc disposed on a hub within the cavity, wherein said rotatable polymer disc has projections distributed around its circumference such that rotation of polymer disc delivers a fixed volume of fluid from the inlet channel to the outlet channel.

15. The flowmeter of claim 14, further including means for detecting the rotation of said polymer disc.

16. A device for controlling fluid flow in microchannels, comprising:

a first and a second intersecting microchannels, wherein said first microchannel includes two spaced apart retaining means;

a mobile monolithic polymer element disposed in said first microchannel and moveable between the retaining means to block fluid flow through said second microchannel; and

means for providing a displacing force to control the movement of said polymer element.

17. A device for controlling fluid flow in microchannels, comprising:

a plurality of microchannels converging at a common intersection,

wherein at least one of said plurality is a fluid inlet, and wherein the common intersection includes spaced apart retaining means and a mobile polymer monolith moveable between the retaining means to block fluid flow into one or more of said plurality of microchannels.

18. A method for shaping a monolithic polymer element disposed within a microchannel, comprising:

exposing the surface of the polymer element to energetic radiation to remove a portion of the surface and thereby shape the polymer element; and

flushing the microchannel with a liquid to remove depolymerized material.

19. The method of claim 18, wherein the source of energetic radiation is a laser.

20. The method of claim 19, wherein the laser is a frequency doubled Argon-ion laser operating at 257 nm.

21. A valve for controlling fluid flow in microchannels, comprising:

a plurality of microchannels in fluid communication with a central microchannel, wherein at least one of said plurality is a fluid inlet, and wherein the central microchannel includes spaced retaining means and a mobile polymer monolith moveable between the retaining means, wherein the polymer monolith, shaped by the method of claim 16, provides for diverting fluid from the fluid inlet and into one or more of the plurality of microchannels.

22. A method of making a mobile, monolith polymer element in a microchannel, comprising:

a) preparing a monomer mixture by mixing together 1,3-

butanedioldiacrylate, tetrahydrofurfuryl alcohol, hexyl alcohol, acryloyloxyethyltrimethylammonium methyl sulfate, and a photoinitiator;

b) preparing a solvent mixture by mixing together acetonitrile, methoxyethanol, and phosphate buffer;

c) mixing together the monomer and solvent mixtures in the ratio of 60:40 by volume;

d) loading the combined mixture into a capillary tube;

e) polymerizing the combined mixture by exposure to UV radiation; and.

f) flushing unreacted monomer from the microchannel.

23. A mobile monolithic polymer element disposed within a microchannel and made by the method of claim 22.

24. A device for controlling fluid flow in a microchannel, comprising

a mobile monolithic polymer element disposed in the microchannel, wherein said polymer element is made by the method of claim 22;

at least one retaining means disposed in the microchannel; and

means for applying a displacing force to the either end of the microchannel.

25. A device for controlling ionic current flow in a microchannel, comprising:

a mobile, monolithic polymer element disposed in the microchannel, wherein said mobile, monolithic polymer element is made by polymerizing a monomer mixture within the microchannel; and

means for providing a displacing force to control the movement of said polymer element in the microchannel.